

Project Report: EFFECTS OF AUDIO SIGNALS ON BRAINWAVES

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During the grant period for the project, November 1, 1980, to November 1, 1981, a total of 84 experimental subjects were tested as to the effects of audio signals on brainwave frequency and amplitude. However, 20 of this number were used for testing of instruments and procedural determinations. Sixty-four experimental subjects were tested once or on several occasions, depending on the nature of the experiments. In addition, eight experimental subjects were tested during verbal communication with a healer and during diagnosis and treatment by the healer.

At this writing, 10 subjects are still involved in an experiment using audio signals to enhance left and right brain hemisphere functions, principally synchronization and as this state affects creativity and learning abilities. It is anticipated that this study will be completed by December 15.

Instruments used to monitor the effects of audio signals on brainwaves were a 5-channel, phase sensitive, EEG biofeedback computer, and two Autogen 120a's that measure frequency and amplitude. Limitations in the instruments were, as regards the former, the incapacity to monitor via the digital recorder, frequency. While frequency could be established for training purposes and feedback by means of audio signalling devices, the digital recorder monitored amplitude only. Further, although five separate locations could be monitored, the use of two or more locations necessitated averaging of the reading. Simultaneous readings could not be obtained. The primary limitation in the Autogen 120a is that it is a single-channel machine. Regardless of the number of electrodes used, only an averaging of the input can be obtained. Further readings are obtained by means of two meters: the frequency meter is marked in increments of 1 Hz, and the amplitude meter in increments of five microvolts. These increments do not provide sufficient sensitivity to accurately monitor state changes.

The Keithley Electrometer-Multiplier 619, used in some of the healer/recipient experiments, appears to be a highly accurate machine, providing extremely sensitive readings in volts, amps, or ohms. With the addition of a strip chart recorder, now on order, this instrument should provide definitive measurements for examining the electrical/energy activity of the human body.

In reviewing the experimental work of the project for the grant period, the results revealed that audio sounds and signals do affect brainwave performance. It can be assumed that sitting comfortably in a lounge in subdued light and with nothing to do will promote relaxation, i.e., lower brainwave frequency and higher amplitude in the lower frequency ranges. However, the experiments demonstrated that certain audio signals produced binaurally, regularly enlisted a deeper state of relaxation than self-induced relaxation, pleasant-experience recall, or other audio sounds, including different kinds of music. These most effective signals were a combination of different signals directed to the left ear then to the right, thus establishing a beat resonance in the alpha-theta ranges and a frequency-following response resulted. The entrainment to these signals became predictable. (See Effects of Audio Signals on Relaxation States as well as earlier study.)

It has been established that the left hemisphere of the brain functions in a linear, sequential, analytical, reasoning fashion in most people, while the right hemisphere is more holistic, spatial, intuitive, and symbolically oriented. For example, language is largely a left brain function while music is a right brain function. Our studies tended to confirm these findings. During the time that the subjects were listening to non-lyrical

classical music, the amplitude (microvolts) in the right brain would nearly equal and sometimes surpass the amplitude in the left brain. However, the moment that lyrics were incorporated in the music, this language quality drew the subjects into greater left brain than right brain amplitude. However, according to our study, some musicians produce greater left brain activity while listening to instrumental music, perhaps because of exercising critical faculties.

Doing mental mathematics elicited higher amplitude in the left hemisphere than the right and produced the largest differential between the two hemispheres.

As some studies (Mankind Research Unlimited, Inc., Iowa State University, Monroe Institute of Applied Sciences, Institute of Suggestology, University of Toronto, and others) have demonstrated that learning, content retention, and creativity are best served when the laterality gives way to synchronicity and both halves produce simultaneously the same or nearly the same frequency and amplitude. Our sessions with the ten experimental subjects training in brainwave synchronization (mentioned earlier and yet to be completed) is designed to determine whether listening to a series of stereo tapes created to promote synchronization will encourage synchronization, and, if so, will enhance learning and creativity. Studies completed to date indicate that the "hemi-sync" signals do produce closer synchronization than relaxation techniques, music, or other audio signals used during the experiments.

The experiments would have been improved if greater control over variables had been maintained. These would include time of day or night, proximity of tests to meals, insulation from phone calls and traffic, etc.

Following are two studies: "Effects of Audio Signals on Relaxation States" and the spin-off experiment with the healer, "EEG Changes During Healing Sessions". Also included, for reference purposes, are portions of two earlier progress reports.

#### EFFECTS OF AUDIO SIGNALS ON RELAXATION STATES

One spin-off experiment was conducted in order to monitor the effects of audio signals, administered binaurally via stereo headphones, on relaxation. The tape was devoid of any verbal instruction, nor were the experimental subjects provided any instruction prior to their listening. They were told only that they would be listening to a stereo tape and that prior to listening some baselines would be established.

Participants were asked to establish self-induced relaxation. After five minutes subjects were asked to do mental mathematics by silently formulating simple equations and solving them. After three minutes of mental mathematics the participants were asked to close their eyes while silently recalling a pleasant experience in as much detail and with as much emotion as possible. Following a five-minute recall period subjects were equipped with headphones and the tape turned on.

The 35-minute tape was imprinted with binaural beats in Alpha, Theta, and Delta ranges eliciting frequency following responses. (See attached chart.)

During the self-induced relaxation period the subjects did not produce deep states of relaxation, remaining in the low Beta states except for the readings from the right temporal lobe where high Alpha was reached. Amplitudes for left temporal, right temporal and occipital lobes were comparable while a somewhat higher amplitude was produced in the frontal lobe.

Readings derived during the mental mathematic exercise provided middle Beta range for the left temporal lobe with moderate amplitude; low Alpha and low amplitude for the right temporal lobe; middle Beta with moderate amplitude for the frontal lobe; high Alpha with low amplitude for the occipital lobe.

The pleasant-recall exercise produced high Alpha in left temporal and occipital lobes and middle Alpha in the right temporal lobe. Amplitude was low in left temporal and occipital lobes and middle Alpha in the right temporal lobe. Amplitude was low in left temporal and occipital lobes while moderate in right temporal and frontal lobes.

Listening to the relaxation tape the participants produced Alpha frequencies from all monitored lobes. The lowest Alpha frequencies from all monitored lobes. The lowest Alpha was produced in the right temporal lobe; the highest in the left temporal lobe. The highest amplitude was produced in the frontal lobe; left and right temporal lobes produced moderate amplitude, and the occipital was low to moderate.

## RELAXATION TEST TAPE

SUBJECT NO. _____ Averaged Scores for Six Subjects	Left Temporal		Right Temporal		Frontal		Occipital	
	Fre.	Ampl.	Fre.	Ampl.	Fre.	Ampl.	Fre.	Ampl.
Self-Induced Relaxation (5 minutes)	14	12.5	13	14.4	15	30.2	16	15
Mental Mathematics (3 minutes)	18	22.4	8	8.5	19	23.4	12	10.5
Pleasant- Experience Recall (5 minutes)	13	10.4	11	21.0	14	22.5	13	9.5
Relaxation Tape (35 minutes)	12	18.5	9	18.5	10	21.5	11	12.5

## Subject #1

	Recipient		Healer	
	Fre.	Ampl.	Fre.	Ampl.
Preparatory Period	13	15	7	40
Discussion	16	25	9	35
Diagnosis	15	35	8	35
Treatment				
(a) Start of	14	30	9	50
(b) Sending (healer) and receiving (recipient) of energy	9	60	8	35
(c) Ending (suggestions of peace & acceptance)	8	35	8	40
Processing (suggestions by healer to relax)	10	30	7	35

## Subject #2

	<u>Recipient</u>		<u>Healer</u>	
	<u>Fre.</u>	<u>Ampl.</u>	<u>Fre.</u>	<u>Ampl.</u>
Preparatory Period	15	10	8	35
Discussion	15	20	10	40
Diagnosis	14	35	8	40
Treatment				
(a) Start of	13	25	9	45
(b) Sending & Receiving	10	45	8	20
(c) Ending	10	30	8	40
Processing	11	35	7	40

## Subject #3

Preparatory Period	9	20	8	45
Discussion	16	30	10	40
Diagnosis	12	25	9	40
Treatment				
(a) Start of	12	20	9	55
(b) Sending and Receiving	8	45	7	25
(c) Ending	8	30	8	40
Processing	11	20	8	35

## Subject #4

Preparatory Period	17	10	9	30
Discussion	15	25	13	25
Diagnosis	16	20	8	45
Treatment				
(a) Start of	14	25	8	50
(b) Sending and Receiving	9	40	7	20
(c) Ending	9	30	8	35
Processing	10	35	8	40

## Subject #5

	<u>Recipient</u>		<u>Healer</u>	
Preparatory Period	12		39	
Discussion	22		36	
Diagnosis	26		41	
Treatment				
(a) Start of	24		52	
(b) Sending (healer) and receiving (recipient)	51		23	
(c) Ending	30		42	
Processing	29		41	

Subject #6	<u>Recipient</u>	<u>Healer</u>
Preparatory Period	14	52
Discussion	27	50
Diagnosis	31	52
Treatment		
(a) Start of	30	61
(b) Sending and receiving	54	29
(c) Ending	32	53
Processing	28	37
Subject #7		
Preparatory Period	22	47
Discussion	23	49
Diagnosis	27	56
Treatment		
(a) Start of	38	59
(b) Sending and receiving	43	18
(c) Ending	21	28
Processing	20	43
Subject #8		
Preparatory Period	9	53
Discussion	18	39
Diagnosis	26	48
Treatment		
(a) Start of	31	67
(b) Sending and receiving	52	28
(c) Ending	41	41
Processing	29	47
<u>Averaged Scores</u>		
Preparatory Period	14.25	47.74
Discussion	22.50	43.50
Diagnosis	27.50	49.25
Treatment		
(a) Start of	30.75	59.75
(b) Sending and receiving	50.00	24.50
(c) Ending	30.00	41.00
Processing	26.50	42.00

With both experimental groups, the healer demonstrated a much higher amplitude than did the recipients during the preparatory period. Describing this state, the healer stated that she endeavored to become relaxed and to "increase the amount of accessible energy".

During the discussion period the recipient's amplitudes were increased, perhaps reflecting greater involvement, and the healer's amplitude decreased a small amount.

Amplitude continued to increase for the recipients during diagnosis, as it did for the healer, perhaps reflecting greater intensity.

During the treatment stages, the amplitudes exhibited by the recipients increased considerably at the time that the healer was "sending energy" to the recipients. Accordingly, the healer's amplitude decreased during the sending state.

Following treatment, the recipients demonstrated a small decrease in amplitude while the healer's amplitude remained approximately the same.

Examining the brainwave frequencies of the four experimental subjects when both subjects and healer were monitored on the Autogen 120a's the recipients exhibited only moderate frequency change, and these remained in the low Beta range, until they "received energy" from the healer. The frequencies then lowered into the low Alpha range. During processing, when the recipients were asked to "accept" and assimilate their experiences, the frequencies still remained in the Alpha range. The healer, on the other hand, went into low Alpha range from the inception of the session and remained there throughout the experiment. The healer's frequency was the lowest during the time she was "sending energy" and at the end of the exercise while withdrawing from healing activity.

#### Progress Report: Audio Signals on Brainwaves

Pursuant to the project "Study of Effects of Audio Signals on Brainwaves," the following report represents investigation of the effects of certain types of music, beats, and audio signals on left and right brain hemisphere frequency and amplitude.

Frequency and amplitude were monitored on two Autogen 120a EEG biofeedback instruments, with one instrument attached via electrodes to F6, T3, T5 locations on the left side of the head and the other instrument attached via electrodes to F8, T4, T6 on the right side of the head.

Subjects were monitored for approximately 45 minutes while listening to stereophonically produced music, beats, and signals. Listening was through stereo headphones. While listening, subjects reclined on a chair-lounger. Lighting in the room was subdued.

Each music, beat and signal section was played for 3½ minutes with 30-second rests between sections. Participants were instructed that the music, beats, and signals would end abruptly and would be followed by a silent rest period before the next section was played.

The following figures represent averaged scores of 17 experimental subjects. As the target is lower frequency (cycles per second) and higher amplitude (measured in microvolts) (to be explained in the final project report), either an "R" for right, "L" for left, or "S" for synchronized follows the percentage figure for "Frequency difference between hemispheres" and "Amplitude difference between hemispheres. These letters indicate which hemisphere achieved the lower frequency and higher amplitude.

## AVERAGED SCORES OF 17 EXPERIMENTAL SUBJECTS

	<u>Right Hemisphere</u>		<u>Left Hemisphere</u>	
	Frequency	Amplitude	Frequency	Amplitude
MOZART	13.1	37.0	15.5	41.8
	Frequency difference between hemispheres .16R			
	Amplitude difference between hemispheres .12L			
BACH	12.8	42.6	12.0	45.2
	Frequency difference between hemispheres .06R			
	Amplitude difference between hemispheres .06L			
SAYER (Come In From The Rain)	13.2	45.8	14.3	64.2
	Frequency difference between hemispheres .08R			
	Amplitude difference between hemispheres .29L			
SAYER (Until The Next Time)	12.4	37.4	13.9	53.8
	Frequency difference between hemispheres .11R			
	Amplitude difference between hemispheres .30L			
ACID ROCK (KISS Group)	15.7	31.2	14.6	46.0
	Frequency difference between hemispheres .07R			
	Amplitude difference between hemispheres .32L			
40 Cycle Beat (60 beats per min.)	13.1	40.9	14.6	43.4
	Frequency difference between hemispheres .10R			
	Amplitude difference between hemispheres .09L			
60 Cycle Beat (60 beats per min.)	12.4	40.1	13.0	43.8
	Frequency difference between hemispheres .05R			
	Amplitude difference between hemispheres .06L			
100 Cycle Beat (100 beats per min)	14.1	36.5	15.2	47.7
	Frequency difference between hemispheres .07R			
	Amplitude difference between hemispheres .22L			
200 Cycle Beat (200 beats per min)	14.9	34.2	14.2	44.0
	Frequency difference between hemispheres .05L			
	Amplitude difference between hemispheres .22L			
BETA HEMISYNC (Monroe tape)	14.3	39.2	14.0	43.2
	Frequency difference between hemispheres .02L			
	Amplitude difference between hemispheres .10L			
ALPHA/THETA HEMISYNC (Monroe)	11.4	46.0	11.3	44.0
	Frequency difference between hemispheres .01R			
	Amplitude difference between hemispheres .04R			

In another experiment, the Fehmi Biofeedback Computer was used to monitor the effects of the same music, beats, and audio signals on three subjects. Amplitude only was monitored from electrodes attached F7, T3, T5 on the left side and electrodes F8, T4, T6 on the right side.

Following are the results of this experiment:

MOZART	11.3	7.1
	Amplitude difference between hemispheres .37R	
BACH	7.5	5.71
	Amplitude difference between hemispheres .09R	
SAYER (Come In From The Rain)	6.4	5.8
	Amplitude difference between hemispheres .34L	

	<u>Right Hemisphere</u>		<u>Left Hemisphere</u>	
	Frequency	Amplitude	Frequency	Amplitude
SAYER (Until The Next Time)		6.3		9.6
		Amplitude difference between hemispheres		.10L
ACID ROCK (KISS Group)		8.2		9.1
		Amplitude difference between hemispheres		.10L
40 Cycle Beat (40 beats per min)		7.0		8.2
		Amplitude difference between hemispheres		.15L
60 Cycle Beat (60 beats per min)		10.4		9.6
		Amplitude difference between hemispheres		.08R
100 Cycle Beat (100 beats per min)		7.7		11.5
		Amplitude difference between hemispheres		.33L
200 Cycle Beat (200 beats per min)		7.9		7.0
		Amplitude difference between hemispheres		.13R
BETA HEMISYNC (Monroe Tape)		9.1		8.5
		Amplitude difference between hemispheres		..07R
ALPHA/THETA HEMISYNC (Monroe Tape)		7.3		6.86
		Amplitude difference between hemispheres		.06R

There may be activities calling for efficiencies best provided by hemisphere laterality, i.e., left-brain or right-brain dominance. However, several studies have indicated that music which incorporates 60 beats per minute, such as Bach's Largo from Concerto in G Minor for Flute and Strings, that was used in this experiment, is particularly conducive to learning and memory retention. This study indicates that listening to Bach stimulates brainwave frequency and amplitude in each hemisphere that are nearly the same, i.e., are close to being synchronized. A 60-cycle beat without music also produced close to brainwave synchronization. The closest synchronization, however, occurred while experimental subjects listened to the Monroe "Beta Hemisync" and "Alpha/Theta Hemisync" audio signals.

Data collected from three subjects monitored for amplitude only reveals that the closest synchronization between left and right hemispheres occurred while the participants listened to the Monroe signals. As with the other experiment, Bach and the 60-cycle beat were close behind.

Averaging of the scores may not be an accurate assessment of the results for obvious reasons and in the final report for the project the results will be analyzed in some detail. Also, the results of Phase I will be synthesized with Phase II results. Plans are for the final report to be completed by November 15. However, the training program involving 12 experimental subjects is not expected to be completed before December 15. The results of this experiment will be tabulated and analyzed at the earliest possible date.

Two spin-off experiments have been completed and the results are currently being tabulated. The first experiment was monitoring the energy exchange between healer and recipient. This measurement was done on an electrometer. The second experiment was monitoring the relaxation level of subjects listening to binaural theta/delta signals.



Quarterly Report: EFFECTS OF AUDIO SIGNALS ON LEFT AND RIGHT BRAINWAVE FUNCTIONS

The effects of audio signals on left and right brainwave functions were administered during Phase I of the experimental project on a total of 43 experimental subjects. However, a number of these subjects were used for testing of equipment and are not included in this study as standardized instrument settings and electrode placement on the scalp were not maintained during these experiments.

Twenty experimental subjects were monitored on a 5-channel, phase sensitive, EEG biofeedback computer (Biofeedback Computers, Inc., Princeton, NJ). Microvolt amplitudes readings were taken from left and right temporal lobes (F7, F8, T5, T6) and frontal lobes.

Subjects reclined on an adjustable lounge during the testing periods and were asked to relax and make themselves as comfortable as possible. Instrument baseline readings were established for each subject following placement of the headstrap and electrodes on the head and while the subject carried on light and non-directed conversation with the experimenter.

Subjects were then requested to mentally solve mathematical problems with eyes closed for approximately seven minutes. They were told the problems could be either simple or complex but that they were to maintain a continuous thought flow.

Subjects were asked to recall with eyes closed a recent day or days which were particularly pleasant to remember. It was suggested that they endeavor to experience the memory in as clear detail as possible. The time allowed for this exercise was ten minutes.

Following the above exercise, stereo headphones were placed on the subjects' heads and they were asked to relax and listen to tapes provided by the Monroe Institute of Applied Sciences, Faber, VA. The tape was approximately 45 minutes duration and only one tape was played during a single session. In developing the tapes, Robert Monroe employed a combination of binaural beats, with different signal combinations being directed to left and right ears, in order to create frequency following responses in left and right brain hemispheres. The tapes used in the study were designed to promote brainwave synchronization between the two hemispheres. The synchronization tapes used were "Hemi-Sync Demonstration", "Hemi-Sync Beta", and "Hemi-Sync Alpha-Theta". One of the tapes employed in the study was Monroe's "Resonant Tuning". While the tape was not designed specifically as a synchronization-producing tool, the investigator discovered while playing the tape and being monitored that a closely synchronized state was produced. As a result of this experience it was decided to use the tape in the study.

Following are the results of the tests:

<u>Average Results on Various Signals</u>	<u>Left</u>	<u>Right</u>	<u>Gross Diff.</u>
Baseline	11.43	9.64	1.79 (left)
Math	11.76	8.24	3.52 (left)
Pleasant Experience	10.36	9.11	1.25 (left)
Res. Tuning	10.27	11.79	1.27 (right)
Hemi. Demo	10.97	11.89	0.92 (right)
Hemi. Beta	11.03	11.85	0.82 (right)
Hemi. Alpha-Theta	11.47	12.99	1.52 (right)

Of the twenty experimental subjects fifteen were right dominant, according to baseline readings, and five were left dominant. The exercise during which subjects worked math problems produced the most hemisphericity and the laterality was to the left. The Hemi-Sync Beta tape produced the closest synchronicity, and the response to the Hemi-Sync Alpha-Theta tape demonstrated the most hemisphericity on the right.

In a second "spin-off" study, employing eight experimental subjects, comparisons were made as to the effects of mathematical problem solving, Jazz-Chuck Mangioni, classical music-Bach's Brandenburg Concerto, and a synchronization tape-Hemi-Sync Alpha-Theta. After establishing baseline levels, subjects were asked to close their eyes and do mental math problems for seven minutes. They then listened to ten minutes each of Jazz, classical, and the signal tapes. Also, during each of the three segments of the tape, the subjects were asked to exert maximum grip pressure with both hands on a digital pressure gauge.

Following are the results of the tests:

Average Results on Various Signals				
	<u>Pds.</u>	<u>Left</u>	<u>Right</u>	<u>Gross Diff.</u>
Baseline	78.88	9.77	7.57	2.20 (left)
Math	78.62	11.37	6.84	4.53 (left)
Jazz	74.62	8.87	6.65	2.22 (right)
Bach	73.63	6.18	7.00	0.82 (right)
Alpha-Theta	76.65	6.32	8.36	2.04 (right)

The eight experimental subjects were equally divided between musicians and non-musicians. Two of the non-musicians demonstrated right brain hemisphericity while listening to both Jazz and Bach. One non-musician produced left hemisphericity on Jazz and left hemisphericity on Bach, while the other non-musician produced the opposite pattern. Two of the musicians demonstrated left hemisphericity on both Jazz and Bach (perhaps being analytical and critical). One musician produced left-brain laterality on Jazz and right on Bach, while the other musician demonstrated the opposite pattern. Seven of the eight subjects demonstrated right-brain laterality while listening to the Alpha-Theta tape. Six subjects demonstrated an increase in strength while listening to the Alpha-Theta tape whereas two demonstrated decreases in strength and these were sufficiently decreased -- for reasons unknown -- to bring down the average. Seven of the eight subjects were left-brain dominant and the other right-brain dominant.